Nitrogen-Gathering Bacteria: Their Share in Farm Fertility

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The history of civilization has largely been a record of man's ability to subjugate the world. His first authority was probably exercised over inanimate objects like stones and logs, which he learned to pile up for his shelter and protection against the elements. Subsequently other objects of wood and stone were obtained and fashioned into the weapons of war and of the chase. From early time mankind has also been engaged in an attempt to harness the animate forms of nature to his advantage. At the early dawn of civilization we find certain animals in the service of mankind, such as the horse and the dog. At a later period we find mankind owning and raising herds of meat cattle. This industry was largely the outcome of his success in subjugating the horse and the dog, by whose aid he was enabled to herd the cattle and reclaim straying animals. It was much later before man appears to have learned to cultivate, in a systematic way, food-giving vegetables, and right down to our present time the addition of new plants or animals to man's domain has claimed some of the most strenuous endeavors of our investigators.

It is strictly in line with this subjugative side of man's activity to press into service the lower forms of life, such as are popularly known as microbes, yeasts and fungi. In the short space of twenty-five years our knowledge of these organisms has increased almost as rapidly as it was formerly lacking. It must not be imagined that because these creatures are small their powers for good or evil are any less than those of the larger creatures. On the contrary, many of them are closer to us in welfare than any of the larger creatures can possibly be which man has subjugated, when we realize that myriads of these organisms live within our bodies, others exist in the food that we take in, while countless numbers inhabit the atmosphere in which we live. The study of these vastly important organisms, like the study of man himself, is one of the last things to which science has turned its investigations.

Spinning Gold From Straw.

The miller's unfortunate daughter in the old fairy tale was allotted the task of spinning straw into gold, and we are told that the preposterous task was finally accomplished by the intervention of a supernatural being, who had the ability to set all things right. In these days we have learned that the myriads of bacteria in the soil are able to accomplish results which seem almost as preposterous as that of the miller's daughter. To obtain fertility from the atmosphere is one of the fairy tales of science which has recently been shown to occur. For a long time it has been known that the atmosphere contains a vast store of nitrogen in the gaseous form, and it has been the ambition of scientific men to utilize this nitrogen in adding fertility to soil.

When the rock-layers disintegrate to form soil they ordinarily produce a soil which contains all of the ordinary elements required for plant food except compounds of nitrogen, for of this latter class of bodies the rocks contain none. Yet, when productive soils are analyzed, for example, the so-called virgin soils, they are found to contain large quantities of nitrogenous material, as much as 5,000 to 10,000 pounds per acre, to a depth of one foot. Chemists have been unanimous in stating the fact that all of this nitrogen has been derived in some way from the large store of gaseous nitrogen in the air.

Possibility of a Nitrogen Famine.

As the question was studied further the constant losses of soil nitrogen?

Losses of Nitrogenous Compounds.

As they became more skilled in analytical methods, the chemists could not remain blind to the fact, which, indeed, all farmers know from experience, that there is a constant drain upon the store of nitrogen compounds in the soil. Considerable amounts are removed by growing plants; another part leaches away into the rivers and ultimately finds its way into the ocean; again, the decomposition of humus transforms some of the nitrogen into gaseous forms which escape to the air. Here, then, comes the puzzling problem. How does this rock powder become the receptacle of enormous amounts of nitrogenous compounds, and by what means does Nature replace the losses of nitrogen seemed to be alarming, because of the large amounts which are constantly lost through various activities of man himself. The sewerage from large cities, which is commonly discharged into rivers, contains large amounts of valuable nitrogen, which are carried into the ocean and lost for agricultural purposes. The burning of wood and coal liberates quantities of nitrogen in the gaseous form, which are added to the large reservoir already present in the atmosphere. The use of nitrogenous compounds in the manufacture of explosives is another serious drain upon the world's supply. It has been repeatedly pointed out that the destruction of nitrates in warfare is hardly less calamitous to a country than any of the other evils which follow in the train of warfare. It is no exaggeration to say that the firing of a large gun on a modern battleship destroys more potential fertility than the raising of hundreds of bushels of wheat. Several years ago Sir William Crookes delivered a public address which prophesied dire calamities when the world's supply of nitrogen should be exhausted. He showed by apparently reliable data that the question of life on the earth was, in reality, a question of the amount of combined nitrogen, and that, when this supply was exhausted, life would be impossible. Those who read and were agitated by such dire prophecies overlooked the fact that plant and animal life had existed on the earth before any of the natural deposits of nitrates had been formed, and that most of the organized life had existed at remote distances from such supplies; consequently, if the earth's nitrogen were a constantly decreasing quantity, life should have been extinct centuries ago. The majority of scientists, instead of being pessimistic, have turned themselves to the more commendable occupation of attempting to learn how nitrates are formed in nature, and whether we can artificially increase their formation in cultivated soils.

The former idea that plants could absorb their nitrogen directly from the atmospheric ocean was soon given up, and it was shown that nitrogen must be combined with other elements to form either ammonia or nitrates before it is available to plants for food.

Different chemists have tried to answer the question by pointing out that small amounts of combined nitrogen, that is, nitrogen compounds, exist in the air in the form of ammonia or of nitric acid. The ammonia arises from decaying organic matter, and the nitric acid is formed by electric discharges, mainly in the course of thunder storms. These theories were, however, discarded when it was shown that the utmost work which could be accomplished by rain and snow in bringing these nitrogen compounds into the soil could not add more than three or four pounds of nitrogen to an acre in the course of a year. Since many times this amount of nitrogen is lost through the processes already mentioned, these theories were obviously inadequate. Not until the rise of modern bacteriology was anything like a promise of solving the question to be perceived. In 1877 proof was afforded that nitrification is a bacterial process and does not take place in soils which are exempt from bacteria.

The Agency of Bacteria.

In the years that have intervened since the first conclusive experiments upon this subject the scientists have given up many new facts and valuable ideas concerning this increase in soil nitrogen through the agency of bacteria. It is true that much yet remains to be learned, but we are now certain that we are on the proper course, and industry and work will bring to light the truth in due course of time. To many ears this alleged discovery was fully as preposterous as the old idea of spinning straw into gold, but modern work has brought about the realization of a process which is more valuable to mankind than the work of old Rumpelstilzchen in the fairy tale. The bacteria which are responsible for this process take the atmospheric nitrogen and combine it with oxygen through various stages until it comes into a condition where it can be utilized by growing crops.

Another interesting fact is that this process appears to go on most abundantly in soil where there is the greatest need for nitrogenous material. In soil that already contains appreciable amounts of nitrogenous material the bacteria become lazy and cease to lay hold upon the atmospheric nitrogen, but in nitrogen-poor soils they are compelled to make use of atmospheric nitrogen in lieu of that which might be obtained from the soil of a rich field. As an instance of the amount of nitrogen which these bacteria are able to accumulate, a single example may be cited. A field belonging to the Rothamstead Experiment Station, in England, was abandoned for twenty-two years, producing nothing but wild vegetation during that time. At the end of the twenty-two years it was found that the soil was richer in nitrogen by an amount equal to 132 pounds of nitrate of soda per acre, in addition to the large amounts which had been consumed by the wild vegetation during the time of the experiment. Thus it was learned that the supply of combined nitrogen to the plant world is maintained through the activities of bacteria. The bacteria which accomplish this result differ from all other classes of bacteria, in that they accomplish an addition of nitrogen compounds to the resources of the plant and animal world, and are known, therefore, as nitrogen-fixing or nitrogen-gathering bacteria. The nitrogen-fixing bacteria may be divided broadly into two classes: those which work alone and those which form partnerships. The former live in the soil itself, and develop there even when no crop is grown upon it. The latter also grow in bare soil, but only accomplish a pronounced power of gathering atmospheric nitrogen after they have invaded the roots of certain leguminous plants, and have attained a certain development there.

Legumes and Nitrogen-Gathering Bacteria.

It need hardly be said that leguminous crops like clover have always shown manifest aptitude to enrich the soil where they have been grown. The fact has been commented upon by such ancient writers as Pliny and Varrus and many others of subsequent times. Opinions differed, however, as to the reason for the soil-enriching qualities of crops like clover. As time went on different students came to more or less universal agreement that the beneficial effects of leguminous crops were in some way related to the formation of small swellings or nodules upon the roots. The exact nature of these nodules was for many years a subject of speculation. Finally, in 1886, at a meeting of scientists in Berlin the problem was solved. Dr. Hellriegel, of Germany, presented proof that the soil-enriching power of legumes was due to the fact that there was associated with them a countless number of nitrogen-fixing bacteria, and that the swellings on the roots were caused by these bacteria. In fact, these nodules were the lodging places of the bacteria. He showed that when clover or cowpeas were planted in a pot of soil where the bacteria had been killed by previously baking it, no nodules were formed. When, however, a pinch of soil from a nodule-forming field was added, bacteria were thereby introduced, and root nodules presently appeared. Since that time scientists have been endeavoring to carry the torch of knowledge into this particular subject of inquiry. The bacteria have been cultivated and studied in laboratories, sorted out and made the recipients of long and well-nigh unpronounceable names; have been introduced into fields of almost all cultivated lands, and their effect upon the various legumes carefully studied. Out of the abundance of results and pseudo-results which have been obtained a few statements may be made with certainty, and the others omitted. We have learned with certainty that the bacteria are more or less restricted to certain legumes. For example, the organism that lives in partnership with peas will not grow with clover, and the organism which lives with clover will not grow with alfalfa nor soy beans. We have also learned that soil which lacks these organisms may be quickly and densely populated with them by introducing a proper inoculating material. This inoculating material may be a few cultures from a scientist's laboratory or a few loads of soil from a neighbor's field where nodules have been produced in abundance upon the roots of a leguminous crop. The best method of inoculation is yet to be discovered, for there are objections to all the methods now in use. A third conclusion which may be drawn from the multitude of experiments is that most of the cultivated soils of the Eastern United States are quite well supplied with all the bacteria necessary for the leguminous crops, with the possible exception of alfalfa and soy beans. The concern of the farmer, therefore, is more in the line of providing suitable conditions for the development and work of these bacteria than in introducing them into his soil. These bacteria will not work in heavy, undrained soils nor in soils altogether lacking in humus, although a small amount seems to suffice for a beginning.

Therefore the most profitable procedure for the farmer, according to our present state of information, is to give the bacteria the square deal. This can be done by frequent plowing, draining wet soil, adding lime to correct sourness, rotating crops and including as many legumes as possible, and, wherever necessary, using the proper inoculating material. In commencing the culture of alfalfa or soy beans inoculating material should always be used, since the crops are not natives of this region and the soils do not naturally contain their appropriate bacteria.

Invitations Issued.

[Special to The Times-Dispatch.]

LYNCHBURG, VA., April 17.—Mr. and Mrs. W. H. Anderson have issued invitations to the marriage of their daughter, Mary, to Lloyd C. Myers, which is to take place April 28 at their home, 1002 Eighth Street.

Very Few Prisoners.

[Special to The Times-Dispatch.]

LYNCHBURG, VA., April 17.—The number of persons confined in the Lynchburg jail now is smaller than it has been for some years, having decreased fully 50 per cent. in the past two months. The number yesterday was forty-six, and only twenty-seven of these were available for chain-gang work.

Russell—Presgraves.

[Special to The Times-Dispatch.]

LEESBURG, VA., April 17.—Miss Rosa Presgraves, the eldest daughter of William Presgraves, of Hillsboro, Loudoun county, was married yesterday afternoon to J. Gordon Russell, of Harper's Ferry, W. Va. The ceremony was performed in the presence of a few intimate friends at the residence of the officiating minister, Rev. W. L. Blakemore, pastor of the Methodist Church, Leesburg.

Fell Under Cars.

[Special to The Times-Dispatch.]

SPENCER, N. C., April 17.—Irvin Brown, aged twenty-five years, a colored brakeman on the Southern yards at Spencer, was instantly killed here yesterday afternoon. While coupling cars he fell under the wheels and was ground to death.